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VALUE ANALYSIS ONE ITERATIVE METHODE FOR DESIGN (PARTH I)
HODNOTOVÁ ANALÝZA ITERAČNÍ METODY PRO DESIGN (ČÁST I)

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Abstract

The paper presents a complete study of VALUE ANALYSIS applied concretely to a selected piece of equipment. The phases and ITERATIVE operation of the Value Analysis method are presented. Value Analysis combines both ENGINEERING and ECONOMICS without, however, placing neither ENGINEERING or ECONOMICS first. They both are similarly important, as can be concluded by the end of this paper. Value Analysis (VA) is a method that provides an operating technique using a creative and organized approach.

Key words: value analysis, value, optimum variant

1. Value analysis applied to the design of a mixer for moulding and core sand preparation

Value Analysis (VA) is a method that provides an operating technique using a creative and organized approach.

It is managed by a group, each of them selected by their expertise in specific subjects and coordinated by a Value Analysis expert.

The VA group activity is managed in seven stages:

- information and functional analysis,
- creativeness,
- evaluation and selection of the proposals,
- the creative phase,
- development of the selected proposals,
- presentation of the selected proposals, set in order by priority,
- implementation phase.

An example of Value Analysis is presented, applied to the redesign of a mixer for moulding sand preparation.

Next the establishing mode of the optimum constructive solution is presented from the technical and economic viewpoint for a part (*Bearing*) participating in a function (*E - Supports the assembly*) of over-dimensioned cost.

2. Establishing the list of technical functions and dimensions

Table 1 presents the list of functions of the mixer.

Table 1 List of functions

Symbol	Function	Type of function	Technical dimension of function		
			Name	UM	Value
A	Loosening and homogenizing	*FS	force	daN	1000
B	Includes components	FS	volume	m ³	0.4
C	Ensures adjustment	FC	height	mm	10 – 25
E	<i>Supports the assembly</i>	<i>FS</i>	<i>force</i>	<i>daN</i>	<i>10000</i>

*FS: Service function; FC: Constraint function; FE: Estimation function.

3. Establishing the levels of importance of the functions

Table 2 presents the value weighting of the functions.

Table 2 Value weighting of the functions (* - X coordinate)

Functions	A	G	H	B	I	F	E	Total
Number of points	7	6	5	4	3	2	1	28
Ratio	0,25	0,21	0,179	0,14	0,11	0,07	0,04	1
*Percentage %	25	21,4	17,9	14,3	10,7	7,14	3,57	100

Step 1

The product value is equal to the sum of the functions levels and is equal to 28. The following percentage values of the functions value weighting result:

$X_A = 25\%$, $X_G = 21.4\%$, $X_H = 17.9\%$, $X_B = 14.3\%$, $X_I = 10.7\%$, $X_F = 7.14\%$, $X_E = 3.57\%$.

Figure 1 shows the studied mixer.

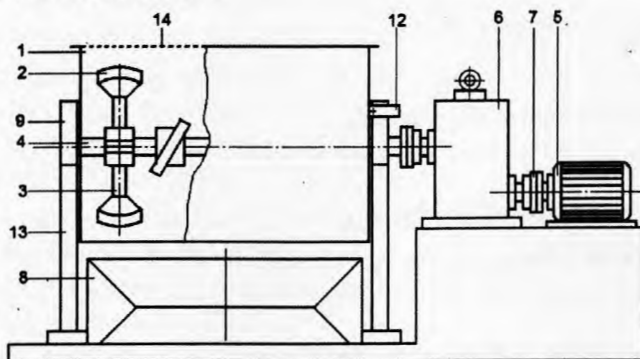


Fig.1 Blade mixer: 1 – tank; 2 – blades; 3 – blade supports; 4 – shaft; 5 – electric motor; 6 – reducing gear; 7 – coupling; 8 – flute; 9 – bearing; 12 – stopper; 13 – frame; 14 – protection grate.

4. Economic dimensioning of the functions

Costs were assigned to the various functions by means of the functions – costs matrix shown in table 3.

Table 3 Distribution of costs on functions (*Y coordinate, ** monetary units)

No.	Parts	F u n c t i o n s							Cost part**
		A	G	H	B	I	F	E	
1	Motor	12				90			102
2	Reducing gear	40				90	90	20	240
3	Tank	10	60	10	10			5	95
4	Blades	30						15	45
5	Bearing			280				15	295
...	...	1170	980	300	750	510	310	203	4223
Total cost		1262	1040	590	760	690	400	258	5000
Ratio		0,25	0,21	0,12	0,15	0,14	0,08	0,05	1
Cost of functions %		25,2	20,8	11,8	15,2	13,8	8	5,16	100

Step 1

The percentage values of the functions participation in the total cost are:

$$Y_A = 25,2 \%, Y_G = 20,8 \%, Y_H = 11,8 \%, Y_B = 15,2 \%, Y_I = 13,8 \%, Y_F = 8 \%, Y_E = 5,16 \%.$$

5. Diagrams

The construction of the diagrams is presented at last.

Based on the values for coordinates x_i and y_i presented in table 4 the diagrams of figures 2, 3, 4 and 5 are plotted. The calculus is made with the smallest squares method.

Table 4 Computational elements for plotting the diagrams. * $S' = 2 \cdot a \cdot (X_i)^2 - 2 \cdot X_i \cdot Y_i$

No.	Elements of calculus	F u n c t i o n s							Total value
		A	G	H	B	I	F	E	
1	X_i	25	21,4	17,9	14,3	10,7	7,14	3,57	100
2	Y_i	25,2	20,8	11,8	15,2	13,8	8	5,16	100
3	$(X_i)^2$	625	459	319	204	115	51	12,8	1786
4	$X_i \cdot Y_i$	631	446	211	217	148	57,1	18,4	1728
5	$(Y_i - a \cdot X_i)^2$	1,1	0	30	1,89	11,8	1,18	2,9	48,89
6	$S' \cdot a$	-52,4	-2,74	196	-39,3	-73,5	-15,5	-12,2	0

Step 1

The parameters have the following computed values: $a = 0.976$, $\square\square 44.31^\circ$,

$$S = 60.95 \text{ and } S' = 0.$$

Table 4 provides the necessary values for constructing the following types of diagrams:

- Diagram of the functions value weighting (fig.2),
- Diagram of the functions cost weighting (fig.3),
- Diagram of the functions value and cost weighting (fig.4),
- Diagram comparing the functional values and costs weighting (fig.5).

Figure 2 shows the ranking of the functions by their value.

Figure 3 shows the ranking of the functions by their functional cost.

The diagram allows significant comparisons of the functions total costs, and within the total costs, of the work and material costs:

- The very expensive functions with the highest weighting in the total cost of the product,
- The secondary functions that are very expensive in relation to the objective functions, or even more expensive than these,

The diagram reveals a Pareto type distribution, meaning that 20 - 30% of the total number of functions, include 70 - 80% of the total costs of the functions. These functions are A and G.

In the case of such a distribution, the first functions in the order of costs, representing 20 - 30% of the total number of functions (in the above example functions A, B and G) are considered to be very expensive functions.

The real situation is represented by the shape of the straight line in figure 4, plotted by means of the smallest squares method, and showing disproportions in the distribution of costs and in the contribution of the various functions to the value of the product.

An analysis of the diagram of figure 4 shows that functions I and E are located above the regression line, indicating high costs, not justifiable in relation to the value.

The disproportions are highlighted also in the diagram of figure 5, where it can be noticed that functions I and E have disproportionate costs (13.8%, 5.16%) in relation to their respective contributions to value (10,7%, 3,6).

These aspects allow the assumption that these functions are deficient, hence the solutions to be identified are to focus on those assemblies, parts, materials and technological operations that contribute, within the general structure of the product, to the achievement of these functions.

6. Criterion of Value Analysis

A basic criterion of Value Analysis is obtaining a minimum value for S' .

In order to diminish estimator S' the points need to be aligned as perfectly as possible along the straight line $y = a * x$, with a tilt of 45° .

Firstly, in order to diminish costs those functions will be redesigned that are located above the straight line.

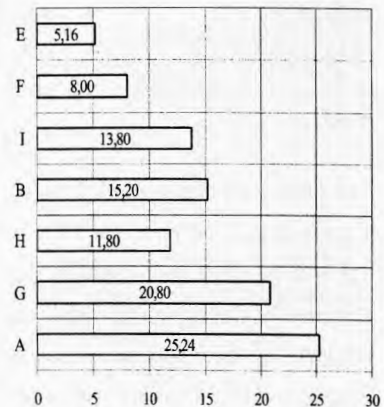
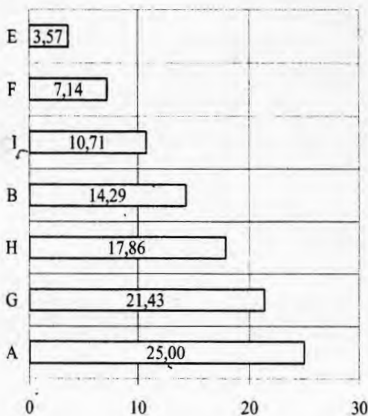


Fig.2 Diagram of the functions value weighting.
Step 1.

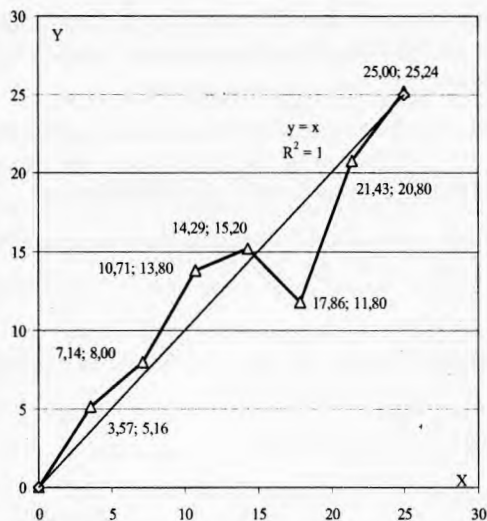


Fig.4 Value and cost weightings of the functions. Step 1.

Fig.3 Diagram of the functions cost weighting. Step 1.

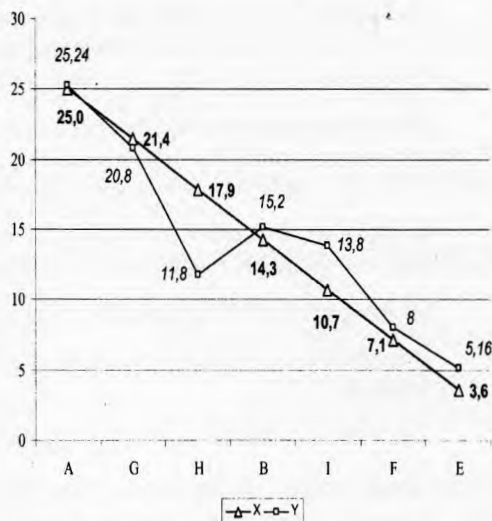


Fig.5 Comparison of values weighting (x---) and functional costs (y-- --). Step 1.

For the points below the line the problems is more complicated. By diminishing the cost of the functions above the straight line, it may change its tilt and the points initially located below the line may appear above it. It is also evident, that by diminishing the cost of certain functions the total costs of the product decreases, the weighting of the functions that were not modified increasing implicitly. This is another cause for some points relocating from below the straight line to above it, without, however, any modification occurring in the absolute value of the costs of these functions.

Secondly, the minimization of S' needs to be understood in the sense of growth the value/cost ratio as much as possible, and not in the sense of imposing $S'=0$.

Thirdly, Value Analysis also admits the increase of the costs of some functions, provided their value increases at a faster rate than the costs.

Practically, the criterion of minimization of S' leads most often to cascading Value Analysis studies, the optimisation of the constructive solution being thus an iterative process.

At first the functions above the regression straight line are analyzed and their costs reduced, then the regression line is re-plotted and the functions relocated above it are noted; these functions too are analyzed in view of reducing their costs, followed by the re-plotting of the regression line, ... etc., etc. Hence the constructive solution is improved from one iteration to the other.

7. Conclusion concerning the existing solution

One of the causes of the disproportions is the distribution of costs on functions for that no certain values are available in all cases, they being the result of approximate averages.

Other causes may appear from answers to the following question:

- Which are the most conclusive criteria and means of critical evaluation for identifying the deficient functions?

The main criterion is the economic one.

This comparison typically yields the conclusion that some functions cost too much in relation to their contribution to the product value and are over dimensioned from the economic viewpoint, the study of solutions having to focus on reducing the achievement costs of these functions.

Interesting and revealing, this modality of critical evaluation entails however the disadvantage of using a scores system for establishing the levels of contribution of the functions to the product value, which is, in essence a subjective operation, that cannot prevent certain assessment errors.

In literature also other modalities for the critical evaluation of functions from the economic dimensions viewpoint are recommended, with more or less limited applicability.

Of these the following should be mentioned:

- Comparison of the achievement costs of the product functions to the same functions of similar products,
- Theoretical computation based evaluation of the costs of a function.

8. Critical evaluation of the functions

The critical evaluation of the functions aims at identifying the deficient functions, which, by their contribution the product functionality and by their constructive and technological achievement have a negative influence on the value/cost ratio.

By identifying the deficient functions the directions of re-conception of the existing product are determined, with a focus on solutions for the constructive and technological achievement of these functions. The critical evaluation of the functions is carried out by the following methods:

- the utility criterion,
- the technical dimension criterion,
- the economic dimension criterion.

9. Evaluation by the utility criterion

The starting point in relation to this criterion is the close examination of the list of functions, in order to identify potentially useless or partially useless functions.

Useless service functions can be identified by relating to user requirements, while useless technical functions result from relating to functionality requirements.

A service function is useless if it is not required by any of the product users (if it does not satisfy any real necessity), and is partially useless if it is required only by a small part of the users.

A technical function is useless if it can be established that it does not condition any service function, and hence does not contribute, from the technical viewpoint, to the product functionality, in its studied constructive concept.

If existing and identified, from the utility aspect deficient functions entail useless achievement costs, which can be eliminated by product re-conception.

10. Evaluation by the technical dimension criterion

The quality of a product is given by the level of its achieved performances. The higher this level, the greater quality and value will be.

In certain cases, however, exceeding certain performance limits leads to costly over quality that does not improve product value.

It is thus possible that certain technical dimensions of product functions exceed the real necessities, meaning that there exists the possibility of technically over dimensioned functions.

In addition to over dimensioning, the critical evaluation of the functions by this criterion allows highlighting also of possible over dimensioning of certain functions.

Identifying solutions for the re-dimensioning of these over dimensioned functions will contribute to improving product value.

Hence functional analysis is followed by the constructive and technological analysis of the product.

11. Evaluation by the economic dimension criterion

The economic dimension or the cost of the function represents the main criterion for the critical evaluation of functions.

These evaluating aim at identifying those functions, the too costly technical solutions of achievement of which affect the total manufacturing cost of the analyzed product.

A correctly completed critical evaluation will directly lead to the identification of what can be called the deficient functions of the analyzed product, that is of those functions that include useless costs.

The deficient functions from the economic viewpoint appear as:

- very expensive functions in relation to the others,
- too expensive functions in relation to the existing technical possibilities of achievement.

Evaluation by the criterion of economic dimension can be achieved in several ways, presented below:

- 1) - comparison of costs per function, by means of the diagram presented in figure 3. This diagram allows comparisons of:
 - the costs of the functions and comparisons of the total cost and the cost of each function,
 - work and material costs, highlighting the very expensive costs, with the highest weighting in the total cost of the product,
 - functions the achievement of which requires disproportionate costs, of either work or material,
- 2) - comparison to the functions of other products. Other products refer to:
 - products of the same typo-dimensional range or family, manufactured by that company,
 - products similar to the analyzed one, manufactured by other companies,
 - products with other destinations, but having some functions similar to those of the analyzed product.

The aim is to identify potential too expensive functions in relation to the existing achieved technical solutions, existing and tested in other products.

It is recommended to relate to the simplest existing technical solutions, that ensure the achievement of the respective functions at minimum costs.

- 3) - theoretical evaluation of the costs of the function. Such an evaluation is possible when a function is determined by a single part or by a small number of parts. Evaluation is carried out in relation to material consumption.

References

- [1]. CHICHERNEA, FL.: Analiza Valorii, Editura Universității Transilvania din Brașov, 2002, ISBN 973 – 8124 – 59 – X
- [2]. CHICHERNEA, FL.: Analiza valorii, ISBN (10) 973 – 635 – 850 – X, ISBN (13) 978 – 635 – 850 – 0, Editura Universității Transilvania Brașov, 2007
- [3]. CHICHERNEA, FL.: Analiza valorii, Universitatea Transilvania Brașov, 2007, CD

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